



U.S. Department of Energy's Office of Science

International Collaborations in the Fusion energy Sciences Program

FY2009 Budget Planning Meeting

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www.ofes.fusion.doe.gov

International Collaboration is a major contributor to the U.S. Fusion Program

- ITER – U.S. burning plasma experiment
 - builds on the confidence gained in the international fusion community over decades of collaborations
- A wide range of collaborations complement the U.S. program elements and enhance scientific results
- Collaborations are evolving from ‘facility orientation’ planning to ‘topical orientation’
 - ITPA at the international level
 - USBPO at the national level
- Facility oriented information is still important for management purposes

International Collaboration is broad, integrated, and it draws on diverse resources in the program

- A. ITER – Well defined Project activities and budget
- B. Most program elements in FES support international collaborations indirectly:
 - i. Major facility programs – ITPA experiments, databases, workshops
 - ii. Stellarator, RFP, HEDP, and diagnostics related collaborations
 - iii. Theory and Modeling activities and validation with experiments
 - iv. Enabling Technologies – hardware development and physics support
- C. Explicit budget line of ‘International Collaborations (IC)’ supports program-wide activities on foreign facilities
- D. ITER design review – new, in response to ITER Org request
 - All scientific exchanges in B and C categories and most of D are carried out through Bilateral, IEA, and IAEA agreements

Outline and Background Information

- Presentation here is for budget planning purposes
 - Elements of ‘International Collaboration’ budget line
 - ITER Design review guidance
- Recent Developments in Collaborations
 - IEA FPCC Study Group on Steady State operations
 - Considerations for restructuring of IEA agreements
 - Broader Approach Agreement between EU and JA
- Background material for information (to be posted)
 - Details of collaborative programs, provided by the program coordinators
 - Status of U.S. Bilateral Agreements

International Collaboration Budget Line is Organized Primarily Around foreign facilities

	(\$ in K)	
	<u>FY 2007</u>	<u>FY 2008</u>
JET	\$2,155	\$2,293
KSTAR	1,539	1,539
Tore Supra	425	425
TJ-II	270	270
JT-60U	175	175
LHD	175	175
EAST	175	175
ASDEX-UG	75	75
TEXTOR	<u>75</u>	<u>75</u>
	\$5,064	\$5,202

U.S. Coordinators of Collaborations on Foreign Facilities

- JET :Jim Strachan
- KSTAR :John Wesley & Hyeon Park
- EAST :Vincent Chan
- Tore Supra/TEXTOR :Don Hillis
- ASDEX-UG :Earl Marmar
- JT-60U :Raffi Nazikian
- Stellarators :Jim Lyon & Mike Zarnstorff

Institutional Participation in International Collaboration Budget Line

(\$ in K)

	<u>FY 2007</u>	<u>FY 2008</u>
PPPL	\$2,289	\$2,427
ORNL	1,419	1,419
GA	585	585
MIT	206	206
LLNL	20	20
Universities*	545	545
Nova	100	100

*Wisconsin, Columbia, UC Davis, Colorado School of Mines

*Each Laboratory has a coordinator
for multiple collaborative activities*

- PPPL : Randy Wilson
 - JET, JT-60U, K-STAR, Stellarators
- ORNL : Don Hillis
 - JET, KSTAR, TS, TEXTOR, ASDEX-UG, Stellarators
- GA :Punit Gohil
 - KSTAR, EAST
- MIT :Earl Marmor
 - JET, KSTAR, EAST
- Individual PIs for grants
 - Whyte, Sabbagh, Cecil, Luhmann, Levinton

Examples of Topical Collaborations under Bilateral and IEA agreements

- **ITER scenario development:** JET, AUG, JT-60U
- **Disruption mitigation** studies on JET,
- **ELM control by stochastic edge** – TEXTOR and JET
- **NTM stabilization** – ASDEX-UG
- **Energetic particle studies** - JET
- **Particle control and plasma facing components** – JET, Tore Supra and TEXTOR,
- **High beta and long pulse integration** – JET and JT-60U
- **Steady state physics and technology:** EAST, KSTAR, SST-1
- **Superconducting tokamak operations** – KSTAR, EAST
- **Diagnostic development** – JET, TEXTOR, EAST, KSTAR
- **Negative Ion Beam development** – JT-60U
- **Concept improvement (stellarator and RFP physics)**

MAJOR U.S. FACILITIES, THEORY & MODELING, AND ENABLING TECHNOLOGIES ARE PARTNERS IN THESE COLLABORATIONS

ITPA-IEA Joint Experiments

- ITPA recommends, IEA implements
- Annual planning meetings of ~ 30 people (leaders of tokamaks in ITER parties, ITPA CC, IEA ExCo)
- Status reports on machine programs and schedules
- Annual program of 60-80 experiments in seven ITPA topical areas
 - ~ 15 % are new experiments;
 - ~ 10 % are closed or discontinued
- JET, AUG, JT-60U, TEXTOR, DIII-D, C-MOD NSTX are major contributors

ITPA/IEA Joint Experiment Planning

(A sample page)

TP-6.1	Transport Physics	Scaling of spontaneous rotation with no external momentum input	J. Rice (CMOD), J. deGrassie (DIII-D), F. Crisanti, L.G. Eriksson (JET), Y. Koide (JT-60U), B. Duval (TCV), A. Field(MAST), C. Fenzi (Tore-Supra), B. LeBlanc(NSTX), J. Noterdaeme(AUG)	CMOD, DIII-D, JET, JT-60U, Tore-Supra, TCV, FTU, MAST, NSTX, AUG	E	Data is not routinely obtained on machines. Even Ohmic data is valuable.
TP-6.2	Transport Physics	JT-60U/DIII-D Mach number scan similarity experiment	C. Petty (DIII-D), E. Doyle (DIII-D), Y. Koide (JT-60U)	DIII-D, JT-60U	E	Co- Counter NBI used to control Mach number
TP-6.3	Transport Physics	NBI-driven momentum transport study	P. Gohil (DIII-D), J. Fujita (JT-60U), M. Peng (NSTX), A. Field (MAST)	DIII-D, JT-60U, NSTX, MAST, AUG	D	Additional definition should be done.
TP-7	Transport Physics	Measure ITG/TEM line splitting and compare to codes	F. Ryter/ C. Angioni (AUG), J. DeBoo/ R. Waltz (DIII-D), V. Vershkov (T-10), C. Bourdelle(Tore-Supra)	AUG, DIII-D, T-10, Tore-Supra, JET	E	Report
TP-8 .1	Transport Physics	ITB Similarity Experiments	M. Peng (NSTX), A. Field (MAST)	MAST, NSTX	E	Report
TP-8.2	Transport Physics	Investigation of rational q effects on ITB formation and expansion	M. Austin (DIII-D), E. Joffrin (JET), K. Razumova(T-10), T. Donne (TEXTOR), E. Joffrin(Tore-Supra)	JET, DIII-D, T-10, TEXTOR, TCV, Tore-Supra, FTU, C-mod	E	Report, Multi-machine discussions of the physics encouraged
TP-8.3	Transport Physics	JT-60U/JET ITB Similarity Experiment	Y Sakamoto (JT-60U), P de Vries/X. Litaudon (JET)	JET, JT-60U	E	
TP-8.4	Transport Physics	T-10/TEXTOR ITB Similarity Experiments	T. Donne (TEXTOR), K. Razumova (T-10), O. Sauter (TCV)	T-10, TEXTOR, TCV, C-mod	E	
TP-9	Transport Physics	H-mode aspect ratio comparison	B. LeBlanc(NSTX), C. Petty (DIII-D), M. Valovic/A. Field (MAST)	NSTX, DIII-D, MAST, T-10	E	Report

A brief status of Foreign Facility Operations

- Most of the major facilities are in operations
- EAST completed its most recent run about a month ago
- KSTAR is expected to produce first plasma in August 2008
- The next VG shows the consolidated operational schedule updated at the November 06 Naka meeting

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
JET												
JT-60U												
DIII-D												
ASDEX Upgrade												
Alcator C-MOD												
Tore Supra												
TEXTOR	no break foreseen unless no change in DED mode											
TCV									~30% in this period			
FTU												
NSTX												
MAST												
T-10	TBD											
T-11M												
Globus-M												
TUMAN-3M												
FT-2												
EAST												
HT-7												
SST-1												

planned provisional

ITER Design Review through Working Groups

- A new activity to establish ITER baseline
 - Physics integration, diagnostics, and interface with RF heating and in-vessel PFC WGs.
- Details of this activity was given by Rich Hawryluk on Tuesday
- Participation is outside the ITER credit system, ‘Voluntary’ contribution
 - cannot use ‘ITER Project funds’ except for those who are in the USIPO staff

*We consider participation in this activity as important
for the success of ITER*

- The U.S. participants in this activity being identified through coordination by:
 - the U.S. members of WG #1 (Hawryluk and Stambaugh),
 - USBPO for physics and VLT for technology
 - USIPO, and
 - Program Leaders
- In coordination with WG Chair (Paul Thomas)

RECENT DEVELOPMENTS IN COLLABORATIONS

- IEA FPCC Working Group on enhancing coordination of Steady State issues
- Possible restructuring of FPCC agreements
- Broader Approach (EU – JA Agreement)
- Fusion Activities in IAEA IFRC

FPCC Working Group on Steady State Physics and Technology

- Established in 2006 to develop a coherent arrangement to coordinate collaborations
 - Physics issues covered in most IEA agreements
 - Technology (engineering physics) not covered
 - New superconducting facilities in preparation
- Motojima and Jacquinet co-chair the WG
 - Several U.S. participants in the WG
 - A summary report presented at the recent FPCC meeting
 - WG will meet again during IAEA TCM/ITPA SSO meeting in Daejeon in May 2007 to identify specific collaborations

Restructuring Considerations of IEA FPCC Agreements

- Nine agreements in three major groupings
 - Tokamak related: Large Tokamaks, Poloidal Divertor (AUG), PWI in TEXTOR
 - Technology and Safety...: Fusion Materials, Nuclear fusion technologies, and ESE (Environment, Safety and Socio-Economics)
 - Alternate Concepts (Stellarators, Reversed Field Pinches, Spherical Torus)
- Close interactions among agreements encouraged
 - Tokamak agreements well coordinated through (ITPA, e.g.)
 - Alternates have more relations with tokamaks than there is among themselves
 - Technology and ESE agreements are increasing coordination
- A need for a new arrangement for steady state issues
- FPCC is considering ways to restructure these in the new ITER era

Broader Approach Agreement between EU and Japan

- Established as a part of ITER site selection
- 10 year Agreement signed on February 5, 2007
 - Japan 46 B Yen, EU 339 M Euros
- Involves three major projects
 - JT-60SA design and construction at Naka (47.3%)
 - IFMIF EVEDA (22 %)
 - International Fusion Energy Research Center (IFERC) with DEMO focus at Rokasho 30.7%
- Agreement is open to participation by other ITER parties; terms to be negotiated

Fusion Activities in IAEA

being reduced due to budget limitations

- Facilitated the ITER agreement
 - Will hold the ITER joint fund
- Continue
 - Fusion Energy journal
 - Bi-annual IAEA Fusion Energy Conference
 - Support future oriented activities (Power Plant studies, e.g.)
- Reduce Technical Committee meetings and Coordinated Research projects

Technical Information from Collaborations to be posted on OFES web-page

- Program coordinators provided extensive information on program activities and highlights on ~ 50 VGs
- These will be posted on the OFES Web-page
[http://www.science.doe.gov/ofes/programnews
.shtml](http://www.science.doe.gov/ofes/programnews.shtml)

Summary and Future Directions

- The new ITER era – an unprecedented international collaboration for the next step in fusion research
 - Provides experience and knowledge to chart the future direction of the U.S. program
 - Accompanied by many other collaborative activities through bilateral and multilateral agreements
- Programmatic collaborations are providing proper priority for most of collaborations through their funding allocations;
- Need to enhance these collaborations with targeted funding of supporting diagnostics, hardware, and additional support through the IC budget line
- We need to prioritize collaborations among different facilities and topical areas based on
 - Programmatic interest in the U.S.
 - their time scales for providing beneficial data